The Kootenay-Rossland Power Transmission.—Part I.

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VOLUME VII. SAN FRANCISCO, MAY, 1899. NUMBER 5.

The Kootenay-Rossland Power Transmission.

BY GEO. P. LOW.

PART I.

KOOTENAY district includes that portion of British Columbia lying on the Canadian boundary immediately north of Spokane, Wash. It is an exceedingly rough country. The crest of the Rocky Mountain range forms its eastern boundary and the Selkirk and Purcell ranges, paralleling the Rockies, run through its center and thus separate it into its east and west divisions, each of which has an average width of from sixty to seventy-five miles, by a length of over two hundred miles. The district is very heavily wooded with dense underbrush or of bleak and barren granitic formation, according to altitude or precipitousness, and the wild, rugged grandeur of mountain scenery, which has, above all other features, made the Canadian Pacific Railway world-famed, is mostly located within its confines. Curious indeed too, are the formation of its lakes and water courses. Inland fresh water seas, almost innumerable, and of all shapes and sizes, mark the country on every hand, and the multitude of rivers supplied from them eloquently bespeak permanence for the sources of the mighty Columbia. Water is everywhere, as are also the Indian and frontier names, euphonious or otherwise, such as the town of Illecillewaet, the Spillimacheen River, or Horse Thief Creek. But an idea of the broken and erratic topography of the Kootenay district can not be better conveyed than by reference to the seeming antipathy which the Columbia and Kootenay rivers bear each other in their early courses.

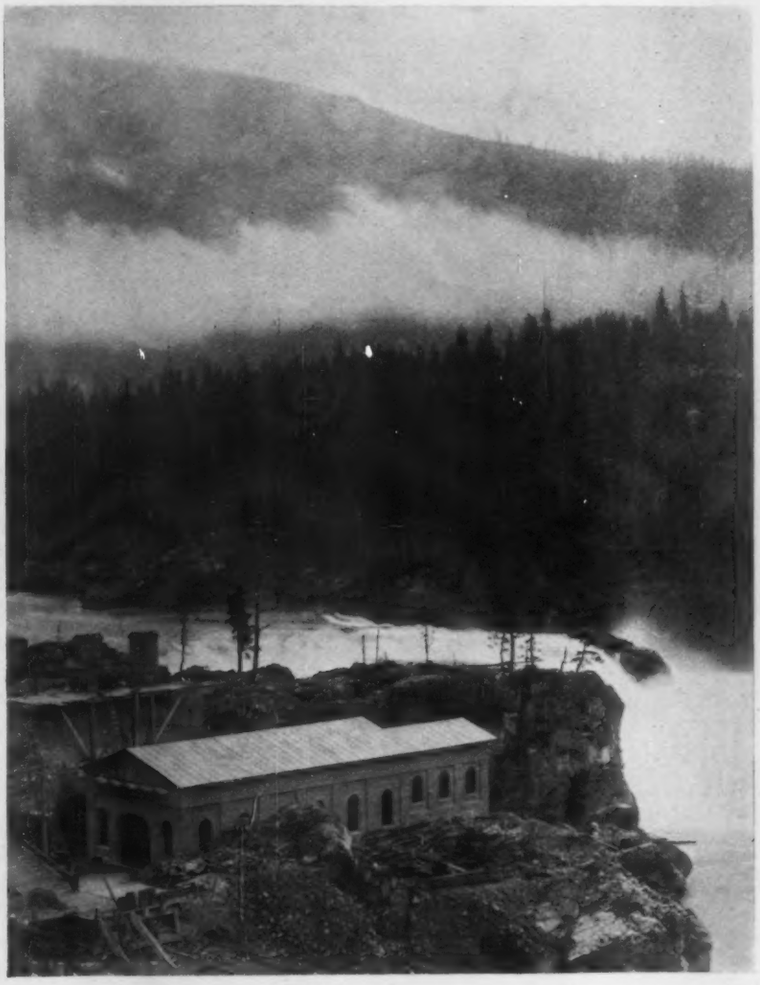

FIGURE 1.—LOWER BONNINGTON FALLS AND POWER HOUSE.

The Columbia has its source in Upper Columbia Lake, whose head or southern extremity is about fifteen miles above the Canadian boundary line. Thence the Columbia flows in an almost due northwesterly direction for practically two hundred miles, whence it turns southerly and then westerly, first through the West Kootenay district and then into the United States and on to the Pacific Ocean.

A few miles east of the Columbia, at a point some sixty miles below its source, are two comparatively small lakes a mile or so apart. From the northerly one the Beaver Foot River rises, eventually reaching the Columbia; in the southerly lake the Kootenay River finds its source and continues down in a southeasterly direction, parallel with and at a distance varying from ten to fifteen miles from the Columbia River, though the streams flow in opposite directions for about sixty miles. When the head of the Columbia is reached and further paralleling is impossible, the Kootenay approaches within three miles of its rival

river but quickly turns from it, flowing away one hundred and fifty miles further south into Montana, whence it retraces its course into British soil and finally joins the Columbia near Robson, some thirty miles north of the boundary line. Before doing so, however, it forms the Kootenay Lake, which is perhaps sixty miles long and from four to eight miles wide, and from the lake it continues to the Columbia through a broad, resistless water course something less than fifty miles in length. It is near the lower end of this portion of the Kootenay River, which forms the connecting link between Kootenay Lake and the Columbia River, that the Bonnington Falls are located, and at the lower Bonnington Falls is the generating station of the West Kootenay Power and Light Company, Limited. Thirty-two miles distant is Rossland, which is one of the newest and most prosperous and promising gold mining camps in British Columbia, and in which electricity is not only fast superceding all other forms of power in mining work, but is also even put to characters of mining service ordinarily classed as impossible of accomplishment. It has been my fortune to make personal examinations of the principal electric power transmissions of the West, and it is without hesitation that I state that in none of them is the West Kootenay transmission exceeded in points of thoroughness, of engineering design and commercial advantage. While the heroic manner in which it has grappled with every phase of the power problem as applied to mines, and the thoroughness with which it has worked out the complete solutions of these problems, enables it to stand alone as one of the most perfect mining transmissions to be found on the Pacific Coast. After long familiarity with experiences which have been had in California transmissions in attempts, generally futile, to operate mining hoists by induction motors, one is quite unprepared on reaching Rossland, to be informed that for months the War Eagle hoist at that place has been operated by a 300 horse-power induction motor and that the service therefrom has been absolutely perfect, so perfect indeed, that the Le Roi mine is to have its steam hoist displaced by a hoist operated by a 500 horse-power induction motor after the plan of the War Eagle hoist as soon as the Kootenay company has enlarged its plant and can furnish power for its operation. All electrical and mechanical details concerning these and many other features of all-important interest will be given in this article.

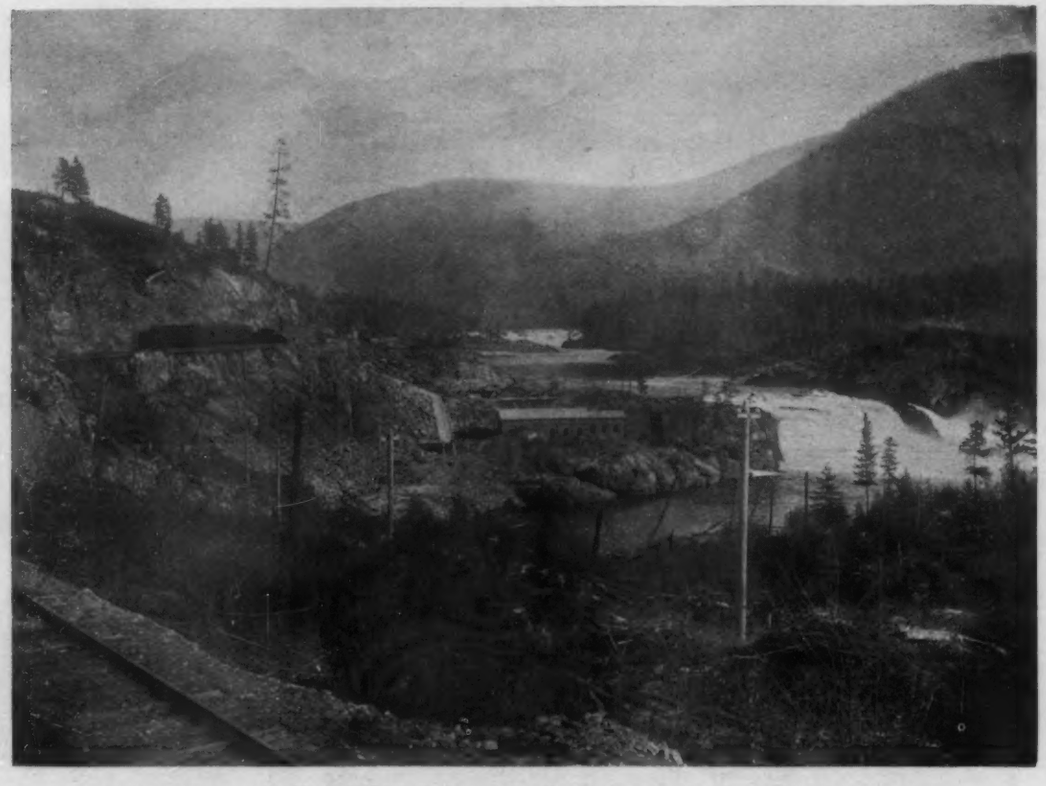

FIGURE 2.—A GENERAL VIEW OF BONNINGTON FALLS AND THE POWER HOUSE.

Among these further features may be briefly enumerated the extraordinary thoroughness and reliability of the water power development, the difficulties which attended the building of the pole line over a rugged route wherein could be found but a few miles of practically level line out of the entire distance, and where, in its length of 32 miles the altitude of the line varies at different points by over 2200 feet. A novelty in the line construction consists in the use of roofed poles and cross-arms, and the Columbia River is crossed with a single span 1500 feet in length without the use of supporting cable. The plant was built essentially for power purposes and of its present load only about twelve per cent. is in lighting, the remainder being in both synchronous and induction motors in mining duty for the operation of compressors, hoists, rock breakers, roasters, bricquetting machines, blowers, machine shops, and other equipments used in and about mining and smelting work.

The general view of the Bonnington Falls, upper and lower, and the country about the power house is given in the accompanying engraving. Here the Selkirk Mountains rise to an elevation of over 1300 feet above the river, or to an elevation of about 3500 feet above the sea level, and the beautifully snow-capped peaks of the rugged range, together with the grandeur of the chain of the falls, forms a charming and picturesque scene. At low water the falls, both upper and lower, are capable of delivering

267,000 horse-power, but the West Kootenay company has thus far attempted to utilize only a portion of the lower falls, which, under the 40 foot head available at extreme low water, are capable of delivering 100,000 horse-power. The river is 400 feet wide at the lower falls and in developing a portion of its water power, the West Kootenay company constructed a canal 650 feet in length

FIGURE 3.—WOODEN AND CONCRETE DAMS AND FOREBAY.

and some 26 feet in width, all through the hard country rock. Towards its lower end the canal widens out into a forebay 54 feet in width, the forebay being closed in by a solid concrete dam 32 feet high and 26 feet in width at the bottom, tapering to six feet in width at the top. Between two high bluffs at a point in the head race, 150 feet above the concrete dam, has been constructed a wooden dam sloping at an angle of 42 degrees up stream and having a vertical height of 44 feet. The sills and timbers of this dam are spaced five feet apart, and all timber, including sills, are of 12×12 material solidly bolted to the rock, the whole being then planked by a double layer of four-inch planking. In the bottom of this dam are five sluice ways and its object is to break the impact of water flowing into the head race from the canal during high water, or, in general, to insure the control of the water entering the forebay at all times.

Lower Bonnington Falls have an extreme difference of level of 32 feet, which measures the head of water available at the power house. The main concrete dam is provided with three feeders, two of nine feet each and one of ten feet. The upper ends of the feeders are closed by gates which measure respectively 12 feet by 13, 12 feet by 13, and 13 feet by 14. These gates are of wood, and consist of a framing of 12×12 timber to which is solidly bolted eight-inch planking. The two outside frames extend upward of 38 feet and to the walls of each pit are bolted the racks for raising and lowering the gates. The gates are further provided each with a small iron floodgate, 12 inches by 12 inches in size, and the main gates are raised and lowered by means of headgate irons rigidly bolted to the top of the dam. The winch controlling the headgate irons are operated by one man. These and other features are admirably shown in the drawing on page 73 showing the end elevation of the dam, power house and tail race. The three steel penstocks, each nine feet in diameter by 20 feet in length, run through the concrete dam into the hydraulic section of the power house near the base of the dam, and from each penstock is carried a ten-inch stand pipe, the height of which nearly reaches the top of the dam. The back of the dam practically forms one side of the power house and tail race, the latter extending at right angles to it and consisting of a pit approximately 30 feet in depth by 20 feet in width, extending nearly the length of the power house, which is 66 feet. In the clear water the tail race is flanked by built masonry and concrete retaining walls which vary from four to six feet in thickness and extend upward to approximately the level of the power house floor. The floor plan of the power house shows the arrangement of the turbines and their mode of connection to the generators. Bolted to the lower end of each penstock is a 13-foot casting containing one pair of 39-inch horizontal cylinder gate turbines. To these castings or wheel housings are bolted the draft tubes, which are 22 feet in length and ten feet in diameter at the lower end. The housing is supported on each end by the retaining walls of the tail race and are further carried by I beams. The turbines for driving the exciters are supplied with water taken from the main turbine housings in the manner shown on the ground plan of the power house.

To be more explicit, the three 40-kilowatt, 125-volt multipolar exciters are direct-driven from independent, horizontal, 12-inch registered gate turbines which are contained in the cast iron flumes, the latter in turn supported by transverse beams bolted to the main beams of the large wheels, while bolted to the cast iron flumes are the draft tubes and feeders. The latter are connected to

FIGURE 4.—REAR VIEW OF POWER HOUSE SHOWING DRAUGHT-TUBE AND TAIL RACE.

the shaftings of the large wheels from which they derive their water supply. The portion of the power house containing the generators and switchboards together with the transformer house built thereon as an L, is bedded on the solid granite rock, which, after being suitably dressed and surfaced with concrete, gave most perfect foundations for the heavy machinery to be placed therein. A single roof

covers the entire structure with the exception of the transformer house which is independently roofed. The building is fireproof, with walls of brick and roof of wood covered with galvanized iron. The inside dimensions of the turbine house are 25 feet by 64 feet; those of the generator room are 31½ feet by 66 feet, while the transformer house measures 17½ feet by 28 feet. A flight of nine stairs takes one from the floor of the generator room to that of the transformer house, the difference in elevation of the two floors furnishing space for the blowers of the air blast transformers and ducts, as will be described hereafter. The height of the building from floor to the ridge of the roof is 40 feet, and ample room is thus provided for substantial framing on which to carry the high tension leads.

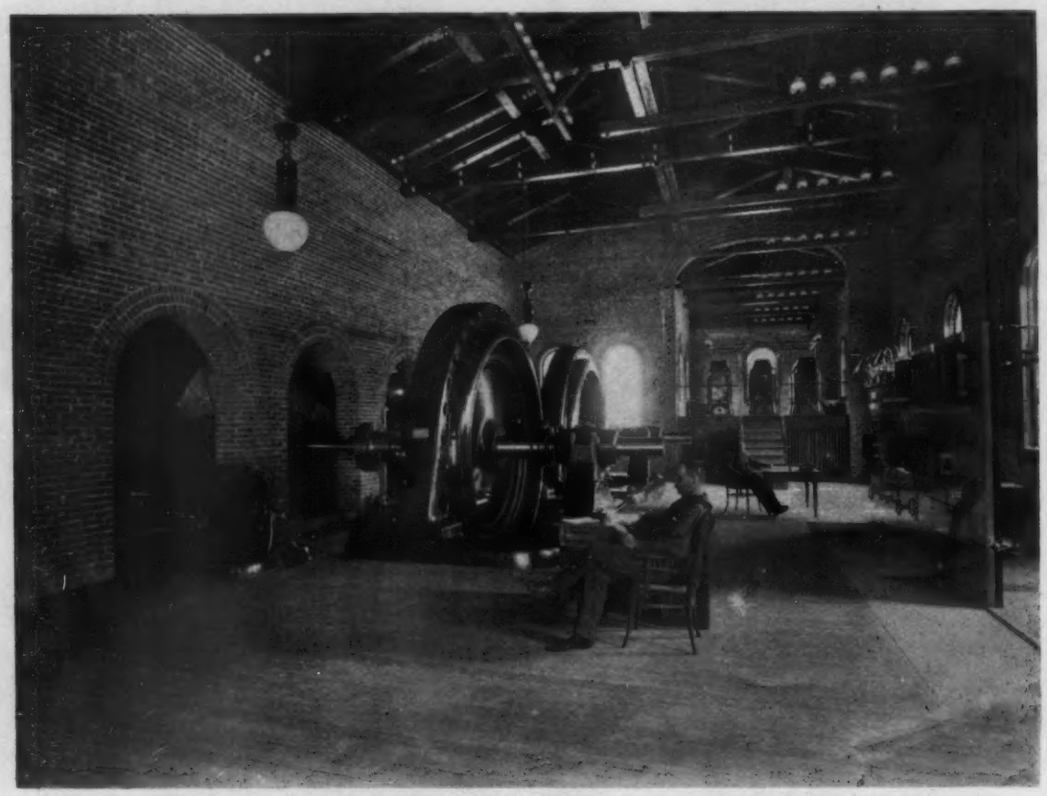

FIGURE 5.—INTERIOR OF THE WEST KOOTENAY POWER HOUSE.

Two 750-kilowatt units have been in operation in this power house since last summer, and the third generator, which is a 1500-kilowatt unit, is at present under erection and will be in operation at the earliest possible moment in order to relieve the overload under which the plant is now laboring, as well as to take care of the increase in business awaiting its installation. Along with this generator, of course, is being erected an equivalent capacity in raising and lowering transformers which explains why these transformers do not appear in the photographs of the plant, although they are shown as erected in the drawings. The comparatively small difference in the relative sizes of 1500 and 750-kilowatt units, even when run under the same speed as is done in the present case, is strikingly shown in the general plan of the power house, from which it is also obvious that two 1500-kilowatt units with accompanying wheels may be substituted for the two 750-kilowatt equipments as installed at any time, if desired, without necessitating changes in the power house.

These generators are of the standard General Electric revolving field type as built by the Canadian General Electric Company, as is also the entire electrical equipment of the whole installation with the exception of the induction motor operating the War Eagle hoist at Rossland, which was built at the Schenectady works of the General Electric Company. The generators run at 180 revolutions per minute, have forty poles, and deliver 60-cycle, three-phase current at 1100 volts delta. Underground waterproof ducts carry the generator leads to the switchboard, which, when completed, will consist of three exciter panels, three generator panels, three transformer panels, and four ine panells. Nothing of novelty is imparted in the switchboard, as all instruments, appliances and methods are of standard General Electric varieties, with the single exception that the generators are thrown into synchronism on the "out" of the synchronizing lamps, whereas it is the usual practice to synchronize with lamps at full candle power. In this connection it is interesting to note that at the outset considerable difficulty was experienced in synchronizing the generators, but the trouble was finally located as being due to the fact that the slip-rings on the revolving fields were out of true one-eighth of an inch. Rotation thus introduced a varying resistance in the contact between the brushes and slip-rings which, though imperceptible in the voltmeter and ammeter readings, made synchronizing an uncertain performance. However doubtful station engineers may be that the trouble experienced was due to the cause ascribed, it is certain that after the slip-rings were turned down no further difficulty was encountered in synchronizing, which is now done with perfect ease under a variation of 200 amperes.

Ducts placed under the floor carry the leads from the transformer panels to the raising transformers. There are twelve of these, each having a capacity of 250 kilowatts and wound for 1100 volts on the primary with either

11,620 volts 20,100 volts on the secondary, according to whether delta or Y. The higher potential of 20,100 volts is delivered to the line.

It is the opinion of the writer that if it had been the general custom to install air-blast transformers in the manner adopted by the West Kootenay Power and Light Company and to have maintained them under the same care and attendance as the Kootenay company is administering to the air-blast transformers in its installation, a greater degree of success would have attended their use than has been the experience of a few of the many transmissions which have adopted them. More detailed reference to this matter will, however, be given in describing the step-down transformer installation at the Rossland sub-station, as the ideas to be conveyed may be then more clearly set forth by reference to the structural drawings

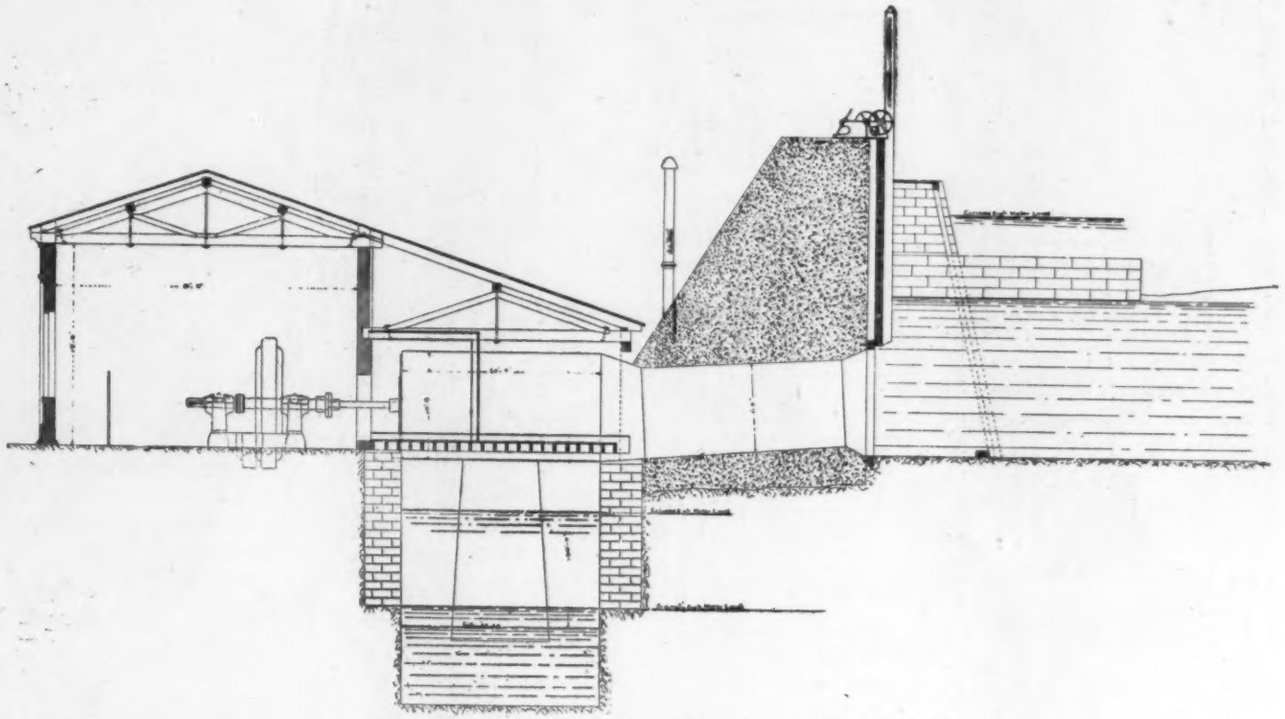

FIGURE 6.—END VIEW OF POWER HOUSE, TAIL RACE AND DAM.

presented, and the principles involved apply equally well to the transformer house at the generating station.

In this transformer house three 60-inch Buffalo blowers together with the two horse-power, 110-volt induction motors from which each is driven, are placed under the platform forming the floor of the transformer house, in the space indicated by the slotted grating behind the stairs. These blowers furnish an air blast to the transformers through large ducts or tunnels after the manner and for the purpose to be described later. The high tension circuits are led from the transformer to porcelain insulators placed on framings overhead in the transformer house and generator room whence they are carried to the line out through eight-inch, vitrified, terra cotta piping built in the front wall of the station. Fifteen such pipes exist, thus providing for five three-phase circuits, and the outside orifices of these outlets are roofed.

THE POLE LINE.

The profile of the Kootenay-Rossland transmission astonishes one because of the extreme irregularity of the country it traverses from one end to the other. In fact it resembles the work of the tracing pen on the recording voltmeter chart of a badly regulated incandescent plant, or perhaps even of a railway power service, much more than the profile of a transmission pole line. There is altogether not over a level mile or two in its whole length, and the grades are of all degrees of steepness, reaching the maximum at about 70 per cent. Its length is practically 31 miles, in traversing which its altitude above sea level varies by over 2200 feet.

Aside from the features enumerated, the pole line embodies two characteristics, each of which is, so far as the writer is aware, without precedent in transmission practice. The pole line is double, and on one of these lines both cross-arms are roofed or snow-shedded. The other distinguishing feature consists in the span of 1500 feet that the line wires take in crossing the Columbia River, these wires being unsupported by cable as will be described. Both pole lines are of a very substantial type of construction, being round, specially selected cedar, and varying in length from 30 to 65 feet, according to location. They are set 100 feet apart, or 50 to the mile, with all corners and curves properly guyed. The right of way lies through a heavily wooded country throughout which a 100-foot clearance has been made from each pole line. The first line built was constructed in the ordinary manner; that is, without roofing, but before it was placed in service the wet snow piled up on the cross-arms to a height of nearly two feet in places, which led to the determination to roof in the second line to prevent any trouble that it was be-

lieved would arise from snow. It should be explained that in the Kootenay country there is no wind whatever during snowstorms and hardly any wind arises at any time during winter. As the snow is of a very wet nature there is nothing to prevent it piling up to the depth named on cross-arms, or its clinging to the transmission lines until the diameter has been increased to four or even six inches, and oftentimes the accumulation will remain until dissipated by the Chinook winds so characteristic of northwestern regions.

The accompanying cuts give the dimensional data of the details and materials used in snow-shedding the second

Two $\frac{3}{4}\times$14-inch machine bolts with 4-inch threads, galvanized.
Four $\frac{3}{8}\times$5-inch machine bolts, standard, galvanized.
Two $\frac{5}{8}\times$4-inch lag screws, standard, galvanized.
Two $\frac{1}{2}\times$7-inch lag screws, standard, galvanized.
Four $\frac{7}{16}$-inch wrought washers, standard, galvanized.
Two $\frac{9}{16}$-inch wrought washers, standard, galvanized.
Four $\frac{3}{16}$-inch cast washers, standard, galvanized.
Four cross-arm braces, $1\frac{1}{4}\times\frac{1}{4}\times$30 inches; holes, 28 inches, centers.
Six high potential insulators.
Two double petticoat glass telephone insulators.
Six locust top pins; shank 2 inches, diameter 5 inches long, standard top.
Two oak top pins, $1\frac{1}{2}$-inch, standard.
One fir cross-arm, 4×5 inches$\times$8 feet, 3 inches.

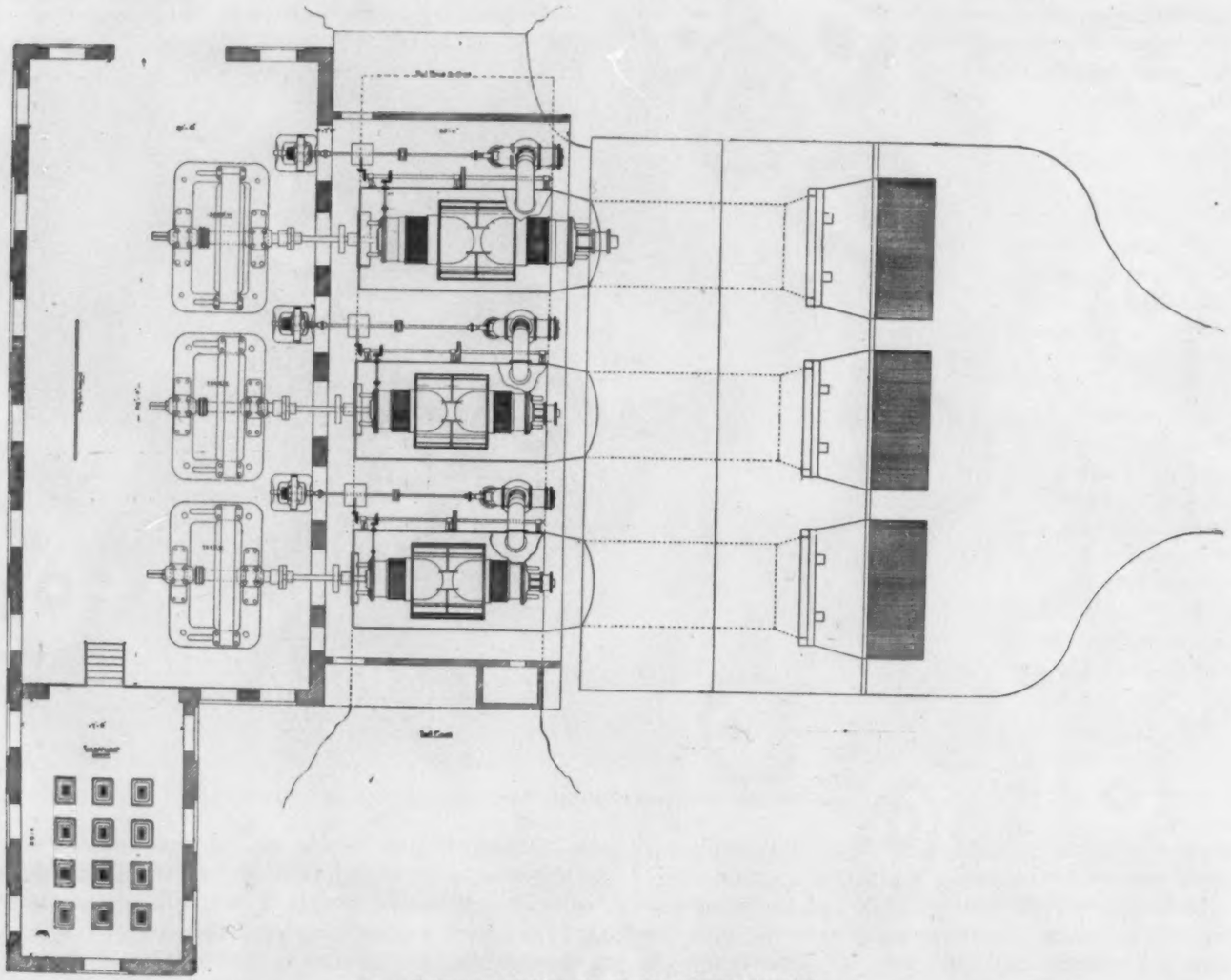

FIGURE 7.—FLOOR PLAN OF POWER HOUSE.

high tension line. As will be seen therefrom both cross-arms are roofed, the upper one, which carries four insulators, being covered with a cedar roofing 24 inches wide, while the width of the roof over the lower arm is but one foot four inches. The details of the construction are, however, given so fully in the drawing on the next page that a description of them would be redundant.

As a matter of engineering information it may be stated that the following comprises the list of materials for each pole:

One fir cross-arm, 4×5 inches$\times$6 feet, 3 inches.
One fir cross-arm, 3×4 inches$\times$2 feet, $3\frac{1}{2}$ inches.
Six pieces cedar, 1×8 inches$\times$4 feet, 6 inches.
Four pieces cedar, 1×8 inches$\times$3 feet.
Four pieces fir, $1\frac{1}{2}\times6$ inches$\times$1 foot, 8 inches.
Four pieces fir, $1\frac{1}{4}\times3$ inches$\times$1 foot, 10 inches.
Four pieces fir, $1\frac{1}{4}\times3$ inches$\times$1 foot, 4 inches.

It will be seen by reference to Figure 10, that the pins used are of specially heavy construction, having a shank $2\frac{7}{8}$ inches in diameter and 5 inches long from the shoulder. The length of the pin over all is $11\frac{1}{2}$ inches, which gives

6½ inches from the top of the cross-arm to the top of the pin. These pins are of locust and the treatment administered to them consisted in boiling them in paraffine oil, after which they were taken out, and when cooled they were dipped in hot paraffine oil. No further treatment

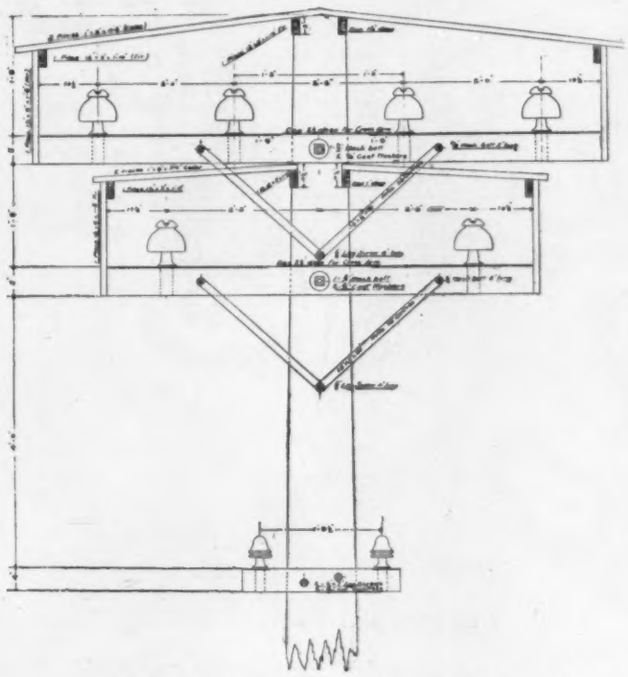

FIGURE 8.—DETAIL OF POLE AND CROSS-ARM.

was given. Porcelain insulators of the Redlands type are used throughout, and while the three wires of a circuit in three-phase transmissions are generally placed so as to form an equilateral triangle, the wires of the Kootenay transmission form an inverted isosceles triangle with 20 inches on the base and 22 inches on each of the sides.

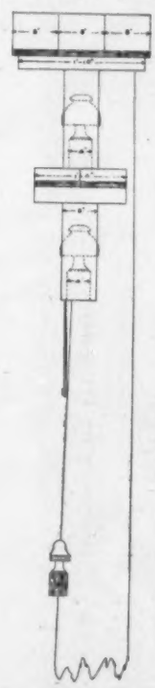

FIGURE 9.—A SIDE VIEW OF POLE AND CROSS-ARM.

The illustration on page 77 was taken from the door of the sub-station in Rossland last winter during a period when the snow had accumulated to a depth of from 10 to 12 inches on the cross-arms of both the roofed and unroofed pole lines. It remained in this condition for considerably over a week and service was continued as usual over both pole lines without interruption from snow or any other cause during this period. If any leakage existed between the wires on the unroofed pole line, or to ground, it was impossible to detect it with the appliances at hand and the standard station instruments were in no wise affected by it to any appreciable degree. It is probable therefore, that after the experience of last winter, such other pole lines as the West Kootenay company may erect will not be roofed.

At present two circuits are completed and have been in successful operation for several months, and the third line is now under construction. These lines are of No. 0, B. & S. gauge medium hard drawn copper wire, with the exception of where they cross the Columbia and Kootenay Rivers, where they are changed to No. 000 bimetallic wire, the increase in cross-section being for the purpose of maintaining the conductivity of the bimetallic wire equal to that had in the regular line. The Kootenay River is crossed in a single span of 600 feet, while the span across the Columbia River is 1500 feet in length. These spans are unusual because of their length and the fact that, as previously stated, they are not supported by strain cables. The methods pursued in crossing each river are the same and on page 76 is given a view of the tower and strain frame on the Rossland side of the Columbia River at the crossing. The No. 0 copper lines terminate at the square strain frame shown near the center of the photograph; and at this point also, the bimetallic lines are anchored and carried thence to the 125-foot tower in front, whence begins the span across the river. There is a sag of 52 feet in the total stretch of 1500 feet, and the strain is supported on ordinary porcelain insulators placed close together and mounted on very substantial framings. At times wet snow has adhered to the line wires at these crossings until it has reached a diameter of about four inches, yet trouble has not arisen therefrom nor from swinging crosses at the rivers, as the separation of six feet that has been placed between wires at these points has proven adequate to prevent it. In fact the service has not been interrupted since the starting of the plant, but on two occasions, one line or the other was broken by the falling of trees that were supposed to be beyond reach of the lines. The photograph showing the tower and strain frames at the Columbia crossing was taken during construction, hence the line wires at the crossing are not shown.

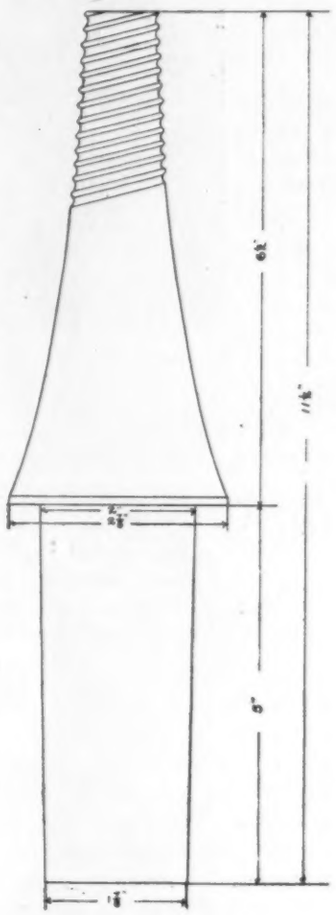

FIGURE 10.—DETAILS OF PIN.

At a point three miles from the sub-station in Rossland branches are taken off at right angles and carried to the town of Trail, B. C., which is four miles by pole line from the main line. At Trail, where is located the great smelter of the Canadian Pacific Railroad, the three-phase

FIGURE 11.—TOWER AND GALLOWS FRAME ON ROSSLAND SIDE OF COLUMBIA RIVER CROSSING.

current is taken into a neat brick sub-station containing the usual equipment of choke coils, lightning arresters, and the high and low tension switchboard panels necessary for the safety and control of the three 135-kilowatt, oil-insulated, air-cooled, static transformers therein. These deliver three-phase current at 550 volts for the operation of various portions of the smelter.

So variegated are the uses to which electric power is put in these premises, and so characteristic is the installation as representing the various kinds of service that may be rendered with the utmost reliability by electric power, that specific reference to the duties performed by some of the motors will be of interest. Two 75-kilowatt synchronous motors, for instance, drive Connorsville blowers for the blast furnace, each motor operating a separate blower, while a third Connorsville blower is driven by a 50 horse-power induction motor. All the remaining motors about the smelter are of the induction type. A 50 horse-power motor drives a rock breaker and another 50 horse-power motor operates the lead mill. The machine shop is driven from a 30 horse-power induction motor; another one drives the O'Heara roasters in the O'Heara building, and a third 30 horse-power motor drives the Bruttner roasters in the Bruttner building. These motors are all of Canadian General Electric manufacture and the only Westinghouse motor about the smelter is a 40 horse-power, type C induction motor which operates a bricquetting machine. The limit of transformer capacity has been reached in the service thus far installed in the Trail smelter, and such eminent satisfaction has resulted from the use of electric power that numerous extensions, among which is to be an electric tramway, are to be installed at once. During the year the Trail line will probably be taken from the main line and carried through to the Rossland sub-station.

(To be concluded in June number.)

FIGURE 12.—THE METHOD OF TRANSPOSITION.

Transmission

SYNCHRONOUS AND INDUCTION MOTORS.*

BY CHARLES F. SCOTT.

ALTERNATING current polyphase motors are of two types, the synchronous motor and the induction motor. Synchronous motors are similar in general to alternating current generators; there are field magnets which are magnetized by a direct current, and the general construction of the machine is similar to that of the generator. In fact the same machine is often used to perform the double function sometimes of motor and sometimes of generator. The speed of the synchronous motor bears an exactly definite ratio to that of the generator which drives it, independent of the load upon the motor. If the maximum capacity of the motor is exceeded it will stop; it

FIGURE 13.—TEN INCHES OF SNOW AND 20,100 VOLTS.

has little torque at low speeds, and is usually started without load, and often a separate motor is used for starting it. Direct current must be provided, usually from a separate machine, for exciting the fields. It is much better adapted for large powers than for small sizes in miscellaneous work.

In the induction motor the currents in one element are not obtained from any external source, but are induced or generated wholly within its own winding, very similar to the currents induced in the secondary of a transformer. When this introduced or secondary element rotates, there need be no brushes nor electrical connection with the windings. The wires from the circuit are connected to the wires in the outer or stationary element, so that there need be no open or moving contact of any kind in connection with the motor. This describes the motor in its simplest form. There are modifications sometimes; the primary element revolves and the currents are introduced by brushes resting on rings, and sometimes the revolving element has windings and resistances which are adjustable either by hand or automatically. These modifications sacrifice some of the elements of a simplicity which is of special value in many kinds of work.

The induction motor tends to run at the same speed as a synchronous motor, which has the same number of poles, but there is a slight falling off in speed, or "slip," which increases as the motor is loaded. The speed variation of the induction motor between no load and full load varies with the size and design of the motor, but does not exceed a few per cent.

The synchronous motor receives power from the circuit very much as a shaft receives power through gearing. The speed is absolutely and rigidly fixed by the driving power. On the other hand, the action of the induction motor is like that of a pulley driven by a belt; there is flexibility, slip. A heavy load does not break any gear teeth nor throw the motor out of step; there is simply greater slip and there is nothing to be feared until belt or motor begins to smoke.

The constant speed induction motor above described, has an overload capacity of several times the full load torque. It is started either by connecting it directly to the circuit, which gives a starting torque considerably greater than the full load torque, or it may have a low electromotive force applied for starting with a reduced torque and a reduction in the current required for starting. Ordinarily, the motor is provided with a double-throw switch, which is thrown in one position for starting and in the other position for running.

The induction motor may have a special winding by which either of two numbers of poles may be secured. For example: A 3600-alternation motor may have either four poles, giving a speed of 900 revolutions per minute, or six poles, giving 600 revolutions, or a motor may have either four poles or eight poles, giving 900 or 450 revolutions. This modification adds something to the cost of the motor.

The induction motor is also made for variable speeds. When running without load the motor runs at the same speed that the corresponding constant speed motor would run, but as it is loaded the speed falls rapidly. The motor starts with greater torque than the constant speed motor. It may be provided with a regulator, by which the electromotive force applied can be varied so that over a wide range the motor can deliver any torque at any speed. This motor is used for cranes, hoists, elevators, and similar work where large starting torques, frequent starting, or variable speed is required.

The description of the induction motor from a mechanical point of view is a negative one—it has no commutator, no collecting rings, no brushes; there is nothing to handle but the switch, and it may be at any distance from the motor; nothing to wear but self-oiling bearings; there are no exposed parts, and there is no sparking and no danger from fire. The alternating current, with its profound and intricate theoretical properties, and polyphase currents with their somewhat confusing relations and reactions, have produced a motor of almost ideal simplicity.

*Abstract from a paper on "Electricity in Paper Making," read before the American Pulp and Paper Association.

Illumination

LUMINOSITY OF A NERNST LAMP IS DECEPTIVE.

A SINGULAR property of the Nernst lamp that is not alluded to in Mr. Swinburne's recently published paper describing it is pointed out by Mr. T. J. Johnston of Schenectady. Mr. Johnston says that its candle-power is, to use his own words, "enough to deceive the very elect. Persons looking at it and at its apparent illuminating power upon the walls of a room, etc., have made the wildest and most extravagant guesses at the photometer reading. I know that," he continues, "although I have had considerable experience with the photometer both in gas and electric lighting work, I guessed 15 candle-power when the Nernst lamp was giving three. I heard one man of more experience than myself guess 32 candle-power when the photometer was reading five. And another thought it was eight candles when the reading was only ¾ of one candle-power. Why this is so, I can not pretend to say."

Chatterton's compound consists of Stockholm tar, 1 part, resin, 1 part, and gutta percha, 3 parts.

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EDITORIAL.

THE NEW TRANSMISSIONS OF THE WEST.

Though it has not been the policy of these columns to publish news notes in editorial form, this has been done from time to time when current events of more than usual interest have transpired. The present time, moreover, is one of great activity in electric transmission work and a trip through the power plants of the Pacific Northwest is one of unfailing interest. Several new plants are now under construction, other enterprises are being projected, and transmissions already in operation are delivering service with the utmost degree of reliability and satisfaction.

The consolidation of the transmission plant of the Pioneer Electric Power Company at Ogden and the Big Cottonwood power plant near Salt Lake City, have resulted in the operation of the Pioneer and Big Cottonwood plants as practically a single station, although they are separated fifty miles. No greater difficulty is experienced in paralleling the generators of these two stations than would be met with were they under a common roof. The Pioneer plant in particular is a superb example of transmission work and nowhere in the country is it possible to find a finer power house or one bearing more numerous evidences of perfect design and management. The load carried by these two stations approaches 4000 horse-power.

Montana has several power transmissions, those to Helena and Missoula being the most prominent, while the transmission from the Big Hole River to Butte, a distance of twenty-two miles, will probably be in operation during the coming summer. This transmission is at present in a peculiar predicament, as will be seen.

Among its many features of interest and novelty, Butte City, Montana, may justly lay claim to possessing the shortest distance high potential transmission line in the world; namely, thirty-three inches at 15,000 volts. This anomalous condition was brought about in this way: Some two years ago the Montana Power Company was organized for the purpose of developing the water power of the Big Hole River at a point about two miles from Divide, on the Oregon Short Line, and electrically transmitting the 4000 horse-power there developed to Butte, 22 miles distant. A crib dam was thrown across the river, the power house was erected, the pole line was built, and the turbines were installed, when, on April 17, 1898, during a freshet, the dam proved itself to be weak by dropping back 14 feet down the river. The entire reconstruction of the dam became a necessity, and further thought of securing power from the Montana Power Company within a year had, perforce, to be abandoned. The new dam is now finished and the early completion of the plant is to be expected.

In the meantime, the steam plants of the Butte General Electric Company in Butte, and to which the Montana Power Company was to have delivered its output, became badly overloaded and the execution of some temporary expedient became necessary to tide over the period until power could be received from the Big Hole transmission. Accordingly, a 750-kilowatt generator, with its complete equipment, including switchboards and raising and lowering transformers, was taken from Divide to Butte, where it was installed, the generator being driven by a twin set of tandem compound Corliss engines. The generator delivers three-phase current at 800 volts to the step-up transformers whence it goes to the step-down transformers over the short transmission named at 15,000 volts, and the lowering transformers deliver 2200 volts to the local lighting distribution circuits, as well as to two induction motors, each of which drives a 125-light Brush arc dynamo direct-connected. Though the arrangement is obviously without the efficiency that would otherwise be attained, it must be remembered that it is the result of abnormal conditions; that it is but temporary, and that its installation was the result of a necessity that became imperative.

The famous Edison station at Spokane will be enlarged during the coming summer by the addition of some six thousand horse-power in monocyclic, street railway, and Edison generators. Work on the foundations of the new station, which is to join the old one on its easterly side, is now in progress and new penstocks and headworks for the same are being installed. Probably the most important electric power transmission to be installed thereabouts is the one going into the Buffalo Hump country near Lewiston, Idaho.

That the Kootenay country, which is across the Canadian boundary line immediately north of Spokane, is not backward in the development of electric power transmission work, will be amply proven by reference to the leading article in this number of THE JOURNAL OF ELECTRICITY. Indeed, it may be said without hesitation that at the present moment the plant of the West Kootenay Power and Light Company is more replete with useful and instructive features than any other transmission throughout the entire West, and it is safe to say that the problems so heroically grappled with in the West Kootenay transmission, and the solutions of which have been so ably worked out, will exercise most far reaching influ-

ences. It is essentially a power transmission plant, lighting being merely an adjunct, and its most remarkable feature is the operation of the War Eagle hoist from a 300 horse-power induction motor with a primary potential of 2300 volts and with such ease and celerity as to even bid defiance to direct current equipment for the same character of service. Details in extenso of this extraordinary hoist are given in the leading article referred to, and it is probable that before the year closes a similar equipment, only of 500 horse-power capacity, will have been placed in the LeRoi mine at Rossland. An extension of the Kootenay transmission into the boundary country, 40 miles beyond Rossland, is also among the probabilities of the near future.

Returning again to the state of Washington, one finds in the Snoqualmie transmission to the cities of Seattle and Tacoma, a plant that excites wonderment because of the extraordinary boldness of some of its engineering features. This plant, together with others herein referred to, will be fully described in these columns in due season, but a suggestion of the magnitude of the work undertaken in the Snoqualmie transmission may now be pertinent. Snoqualmie Falls have a sheer drop of 268 feet, or, to convey a comparison, imagine a stream of water as wide as the Claus Spreckels Building, San Francisco, falling from a height equivalent to the base of its dome and varying in thickness from seven to twenty feet at its crest, and some idea will be conveyed of the grandeur of Snoqualmie Falls. The power house has been cut out of the solid basalt over which the falls leap. A shaft ten feet in width by twenty-five feet in length, and approximately 260 feet in depth has been sunk on the river bank a short distance above the falls. At the bottom of this shaft a cavern 35 feet in height, by 40 feet in width, by 200 feet in length, has been cut out of the solid rock, and from the lower end of this a tunnel or tail race ten feet wide, by 20 feet high, by 500 feet in length, has been cut to an outlet below the falls. In this cavern all water wheels and generating equipment, consisting of six 1500-kilowatt, 1000-volt revolving armature three-phasers are being installed, the raising transformers being located in a transformer house at the mouth of the shaft. The transmission line as heretofore described in these columns is of aluminum supported on Locke glass insulators, and here it may be stated that in the opinion of the writer, who has been on the ground and has made a personal examination of the transmission, no evidence of either scaling or pitting or other disintegration or impairment of any kind could be found in the aluminum wires on the Snoqualmie line. Emphasis is placed on this point because of reports that have been persistently circulated anent aluminum in this interesting line. It is probable that the plant will be in operation in July.

As a result of the completion of the Snoqualmie line, it is probable that a very interesting fight will be waged for the control of the lighting and power business of the two chief cities of the Sound. The various railway systems of Seattle have progressed with a consolidation so far as it is possible to go until the city shall have granted a new blanket franchise. This secured, some of the electric lighting companies will probably enter the combination, in which event, all railway and lighting service will be rendered from a single plant, but whether this plant shall be a steam station or the proposed transmission from Cedar River remains to be seen. The Cedar River transmission impresses the visitor to Seattle as being beset with many difficulties in the way of its early accomplishment, and in any event it is probable that before it can be put into operation the consolidation referred to will have been effected creating a demand for a union power station which will be met by the erection of a steam plant on the water front. With coal $1.25 per ton, steam should produce electric power as cheaply if not cheaper than a long transmission that is expensive to install and heavily bonded. The Seattle Gas and Electric Company will, in all probability, hold aloof from a combination, and it gives evidence of preparing to hold its own through the installation of producer gas generators and gas engines, driving electric generators. The Snoqualmie plant will therefore be the third and last party to the triangular fight, and although the business is at present practically entirely in the hands of its opponents, it is probable that in the long run it will make a more than favorable showing, mainly because of the fact that its plant was built by private parties on a spot cash basis, while the bonded indebtedness of its competitors more than quadruples its cost. To the onlooker it appears that finesse and broadly capable business management are all that are necessary to bring the Snoqualmie transmission to satisfactory commercial attainment.

AN INEXCUSABLE FAILURE.

Rumors are persistent through Rocky Mountain regions that the operators of the Golden Gate Mill at Mercur, Utah, have become dissatisfied with the use of electric power therein, and have given orders for the installation of a steam plant with which to entirely displace the use of electric power. Time has not permitted the confirmation of these reports by correspondence, and, in fact, the sources from which the information has been received are such as to make it appear that further confirmation is unnecessary, hence the belief is held that the rumors given are true.

However reluctant a journal may be to publish statements reflecting against the industry it represents, it is, nevertheless, its duty to its colleagues and to itself to hide no evidence which, in its absence, would conceal a fact that might have material bearing in solving the problems of power transmissions. The Golden Gate Mill was operated from the generating station at Provo Canyon, Utah, whence power was transmitted at an initial potential of 40,000 volts to Mercur as well as to the mines of the Tintic district. The Provo-Mercur transmission has been fully described in these columns heretofore,* and is also extensively referred to in Mr. Chas. F. Scott's article on High Potential Power Transmission.† It has long held the distinction of being the highest potential power transmis-

*JOURNAL OF ELECTRICITY, Vol. V, No. 6, page 169, June, 1898.
†*Ibid.*, Vol. VI, No. 6, December, 1898.

sion in commercial operation, though its voltage is nearly equaled by that of the Southern California Power Company, which has now been in operation at 33,000 volts for several months.

It is especially unfortunate that the operators of the Golden Gate Mill found it necessary to take steps anticipating the abandonment of electric power for several reasons, first among which is the fact that the installation has been widely advertised as approaching the acme of perfection in the operation of mills of this character from extremely high potential circuits. Secondly, and which is to be deplored the more, because the proposed abandonment of electric power, though in no wise chargeable to any dissatisfaction whatever in the operation or efficiency of motors, transformers, or other similar appliances, is due to the flimsy construction of the pole line, the rendering of reliable service over which has been proven to be impossible. As reported in Mr. Scott's paper, as well as in THE JOURNAL OF ELECTRICITY article which preceded it, no trouble has arisen from the use of the line potential of 40,000 volts, and therefore, neither the pins nor insulators have proven defective, but the reports received have been unanimous on the point that the unreliability of the Provo-Mercur transmission has been due solely to the use of light poles, and, in brief, to a generally cheap pole line construction over a mountainous country, where, especially considering the climatic and atmospheric exposures to the line and the necessity for delivering continuous service, the pole line should have been of the most substantial and stable construction possible. It is stated that during the past winter the interruptions to the electric power service in the Golden Gate Mill have numbered as high as fourteen per month, all due to the cause stated.

It is to be added that the failure of electric power service in Mercur is obviously due to other than electrical causes. It must clearly be classed as a preventible failure, in no wise chargeable to its electrical equipment in any portion, nor to the use of 40,000 volts even in an extremely mountainous country at a high altitude, but instead, let the blame rest where it belongs: to short-sightedness in the building of an unworthy pole line.

Passing Comment

An Editorial Review of Current Events and Comtemporary Publications.

A "JOKER" IN WELSBACH LIGHTING.

The daily press of San Francisco has, of late, contained much concerning the relative merits of the gases produced by two rival gas companies, and the contest between them wages with fast embittering strife. The situation is not without moment to the gas world, and being such, it is interesting to offer comment on a point brought out in the following press clipping:

The San Francisco Gas and Electric Company yesterday invited the Mayor and members of the Board of Supervisors to witness a test at 116 Stockton street of the relative values of their illuminant and that manufactured by the Equitable Gas Company. President Ackerman and Dr. Chisholm of the Equitable company were also guests of the old company. There was a lengthy argument between Dr. Chisholm and President Crockett, in which the former protested that the apparatus to be used would not give a fair test to two gases so thoroughly different. After much wrangling there was an exhibition of what the old company could do with both gases when they were subjected to its apparatus. Then, in reply to a challenge by the Equitable's president, there was an adjournment to his offices, where the dollar gas was tested with a much different result than that secured in the laboratory of the old company. At the laboratory the dollar gas was but a dim representative of what an illuminant should be, but in its own home its brilliancy could not be questioned. A comparative test with the production of the old company drawn directly from the regular pipes gave to the dollar gas practically an equality as regards the amount required to fill a Welsbach burner.

The contention of the San Francisco company is that the Equitable gas, which is made by the Hall process, has but about half the heat units possessed by the carburetted water gas of the former company. This statement is contested by Dr. Chisholm, executive officer of the Equitable company, who claims that the calorific power of the Hall gas practically equals that of the old company.

Without passing upon this question in any manner at present, let it be assumed that the claim advanced by the San Francisco company is correct, and that, therefore, the Hall gas contains, say, 350 British thermal units, and the San Francisco gas contains 700 British thermal units. The former gas is of 11 candle-power, while the latter is of 22 candle-power. Query: What are the relative values of the two gases for (1) open jet lighting, (2) heating, (3) power, and (4) incandescent gas or Welsbach lighting, it being further assumed that equal volumes of gas at equal pressure are consumed in each case.

The first three questions are quickly decided, for it is obvious that in each case the value of the Hall gas (under the assumptions stated) would be but one-half that of the San Francisco gas; that is, burned in an open jet, but one half the light; in a gas stove, but one-half the heat; and in a gas engine, but one-half the power, would result from the use of the Hall gas as would be available from the carburetted water gas of the older company—*if the assumption holds true.* These facts are by far too evident to require proofs.

As to the Welsbach, one of the ablest authorities on gas engineering has stated to the effect that a given quantity of 350-heat unit gas, if applied to a Welsbach mantle through an argand burner, will heat the mantle to as high a degree of incandescence as will be done by an equal quantity of 700-heat unit gas applied to the mantle through a bunsen burner. The authority referred to is none other than Prof. Vivian B. Lewes, chemist of the Royal Naval College, Greenwich, England, and his exact words on the subject are as follows:*

The combustion of water gas only develops half the thermal value that is to be obtained from an equal volume of coal gas, and many theorists imagine from this that its power of developing light from a mantle would be less in the same ratio. This, however, is an error, as the gas, being non-luminous, is burned in a burner of the argand type without previous admixture with air, giving a very intense combustion on the surface of the mantle, where the gas and air meet, and thus developing a higher illumi-

*From "Water Gas: Its Past, Present and Future," by Prof. Vivian B. Lewes, *Gas World*, London, Vol. XXVIII, No. 721, page 750, 1898.

nating value than could be got from the coal gas in an atmospheric burner.

The water gas referred to in the paragraph quoted is "straight," or uncarburetted water gas, which is the virtual equivalent of the Hall gas in heat units; "coal gas" is the equivalent of carburetted water gas, such as is furnished by the San Francisco company, and an "atmospheric burner" is a bunsen burner. In other words, and under the assumptions made, the bunsen burner as applied to Welsbach lighting, has but half the efficiency of the argand; and, on the other hand, it appears that the high candle-power gas, *i. e.*, the 700-heat unit gas, cannot be applied to a mantle through an argand, probably because of its hydrocarbons. Being inherently different, they must be applied differently, and the relative values of the two gases for Welsbach lighting, under the assumptions made, appear, therefore, to be about equal.

But arbitrary assumption and incontrovertible evidence concerning consumption and calorific values of gases, are by no means equally stable foundations upon which to build a superstructure of conclusions; hence the foregoing is speculative, rather than conclusive. Of the latter, more anon.

Physics

MEASUREMENT OF LOW TEMPERATURES.*

BY WALTER H. DICKERSON, M. E.

THERE are three methods of measuring the low temperatures of liquid air, namely: the hydrogen thermometer, the thermo-pile or thermo-electric couple, and the platinum thermometer. The correct reading of these thermometers all depend on the assumption that the laws which govern their actions at ordinary temperatures, hold good at these extremely low temperatures; consequently, the temperature determinations based on these assumptions can only be taken as approximately correct.

In using the hydrogen thermometer to measure temperature as low as that of liquid air, it is open to the criticism that such temperatures approach the critical point of hydrogen, and this introduces a great chance of error.

In using the thermo-pile or thermo-electric couple, it is calibrated at ordinary temperatures, and a calibration curve plotted. Assuming that the curve conforms to the same laws throughout a wide range of temperature, the curve is exterpolated to cover low temperature readings. The instrument readings are taken at the low temperature and plotted back upon the exterpolated portion of the curve and the temperature then determined.

The platinum thermometer is probably the most reliable of the three, and has been used by most of the European investigators in the greater part of their researches in low temperatures. It consists of simply a fine pure platinum wire, sometimes bare, and sometimes sealed in a small glass bulb, and intended to be placed in the liquid, the temperature of which is to be measured. In using it, its resistance-temperature curve is plotted, a given resistance corresponding to a definite temperature. The resistance-temperature curve of pure platinum, for ordinary and high temperatures, is very nearly a straight line, and produced, passes through the origin of co-ordinates, a portion corresponding to zero resistance and zero temperatures. The resistance of the thermometer being determined, it is plotted on the curve and the temperature deduced. The temperatures thus deduced, depending as they do on an assumption, are always expressed as platinum-Centigrade, or platinum-Fahrenheit, degrees.—*Stevens' Indicator.*

THE FERRARIS-ARNÓ PHASE TRANSFORMER.

ONE of the novelties of the exhibit of Messrs. Ganz at the recent Turin International Exhibition, was a distributing system on the Ferraris-Arnó system, which is described in *The Electrician* of February 3d. This method was suggested by Prof. Ferraris a few months before his death, and it has been successfully worked out by his distinguished assistant, Prof. Arnó.

Suppose an alternating current motor has four coils, A, A', B, B', set at right angles and connected as shown in Figure 1. If two alternating currents differing 90 degrees in phase are sent through them as shown in the diagram, a rotary field will be produced, and if the armature is given a definite polarity, it will rotate at the same speed as the field. Now if the circuit $B\ B'$ be opened, the motor will work as a single-phase synchronous motor, and it will at the same time generate an electromotive force at the terminals of the circuit $B\ B'$, differing 90 degrees in phase from the primary current in $A\ A'$. Once started, therefore, the motor acts as a transformer, the electromotive force in the secondary $B\ B'$ depending on the number of turns in the coils.

With the aid of a stationary transformer connected across the primary as shown in Figure 2, the electromotive force induced in the circuit $B\ B'$ may be made two-phase, although the current in the primary is only single-phase. It is also possible to have three wires in the secondary circuit, making a two-phase three-wire distribution, by following the connections given in Figure 3. This latter method of connection is used especially for starting motors, with the aid of a third wire from one of the transformers. Messrs. Ganz had nine motors in various parts of the exhibition, started on this principle.

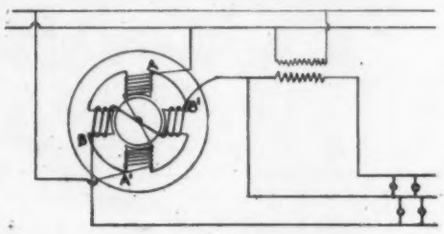

FIGURE 1.

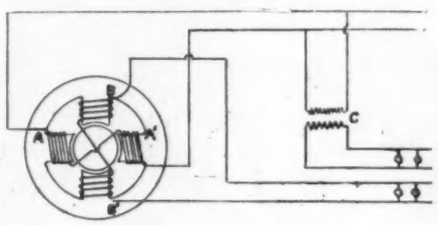

FIGURE 2.

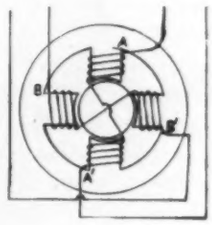

FIGURE 3.

Gas

GAS ENGINES IN ENGLISH ELECTRICAL STATIONS.

GAS engines for operating electric lighting plants are in more common use in Great Britain than in this country, and it is interesting to note the results of inquiries sent by Oliver F. Allen to 35 such plants. Of the 24 replies which he received, the writers of 15 are entirely satisfied and have had no trouble; four have had some trouble with igniters; one has had trouble in starting with a cold cylinder; one engine requires too much attention; one is not able to give information on account of the plant not having been put in operation; one is doubtful, and one is condemnatory. Seventeen of the engines reported are from 30 to 125 horsepower in size, and the owners of the larger engines particularly, express much satisfaction from their use. The gas consumption reported varies from 13.6 to 30 cubic feet per brake horse-power on the basis of 650 heat unit gas. Various makers communicated with guaranteed consumption ranging from 15 to 20 brake horse-power.

INDUSTRIAL GAS.—II.

BY FRANK H. BATES.

THE ELLIOTT APPARATUS. By means of the apparatus already described, it was only possible to analyze a mixture of gases containing carbon dioxide, ethylene (illuminants), oxygen, and carbon monoxide. When it is desirable to ascertain the composition of a mixture containing hydrogen or methane as found in producer gas, illuminating gas, etc., recourse must be had to apparatus which affords a means of burning these gases with oxygen, a measurement of the products of combustion, together with the contraction, enabling one to compute the volumes burned. With Dr. Elliott's apparatus such a determination may be made very rapidly, although at the expense of great accuracy. Owing to the explosion, over water, of the residual gas (the portion remaining after the absorbable constituents are removed), the error of results may be as great as two per cent., although the total error may generally be kept within one per cent., which will meet the requirements of technical work. In iron and steel works, metallurgical establishments, for glass-ovens, and regenerative furnaces using producer gas, and for the analysis of chimney or flue gases, the "Elliott" makes possible sufficiently rapid work to enable the operator to keep in constant touch with the various changes taking place.

The principal innovation with this apparatus lies in the treatment of the gases by permitting the reagents to spread and run down the sides of a long tube containing the gas mixture, bringing the absorbent in intimate contact with loss of but little time.

Description. It consists of an absorption tube A (Figure 4), measuring burette B, and explosion burette C, all graduated to 100 cubic centimeters, although of but one-half the indicated capacity. The two burettes, B and C, are divisioned in tenths of cubic centimeters. The bulbs, at the junction of the tubes A and B with the capillary tubing, serve to render the apparatus more compact by lessening the height, and, in the case of the absorption tube A, provides a means of spreading the liquid reagents used. At the lower end of the absorption tube A is inserted, by means of a cork C′, an arm of capillary tubing, which communicates by the three-way stop-cock D′ with the level-bottle M, through the arm E′ and rubber tubing fastened thereon, and affords an exit for the discharge of reagents by way of the arm V. Above the horizontal capillary on the tube A is a stop-cock B′ communicating with the open end A′, ground tapering to receive the funnel F′ by which the reagents are introduced. The horizontal capillary just below is cut off square at the ends I′ and J′ to permit of a piece of glass capillary tubing G, being inserted to form a close joint with a short piece of rubber tubing H holding it in place. A similar arrangement is provided for the ends K′ and L′, thus connecting the three tubes. The lower ends of the measuring and explosion burettes are drawn out to receive rubber tubing with which to connect with the level-bottles N and P. It is advisable to fasten the rubber tubing on the projecting ends by wire ligatures, necessitating the use of three level-bottles, which is preferable, in the writer's opinion, to loose connections and frequent interchange, as is the case when but two are used, as supplied by the makers.

Near the lower end of the explosion burette, below the rubber stopper R′ of the water-jacket W, projects an arm of capillary tubing U′ with a stop-cock T′, through which to introduce the air and oxygen (or hydrogen) used in the combustion of the residual gas. Above the rubber stopper Q of the water-jacket, are fused two platinum wires P′ for an ignition spark. The water-jacket W serves to prevent undue heating of the burette during combustion, saving time which would otherwise be required for its cooling. As directed in connection with the Orsat, when the measuring burette is subject to changes of temperature during an analysis, it should also be water-jacketed. The

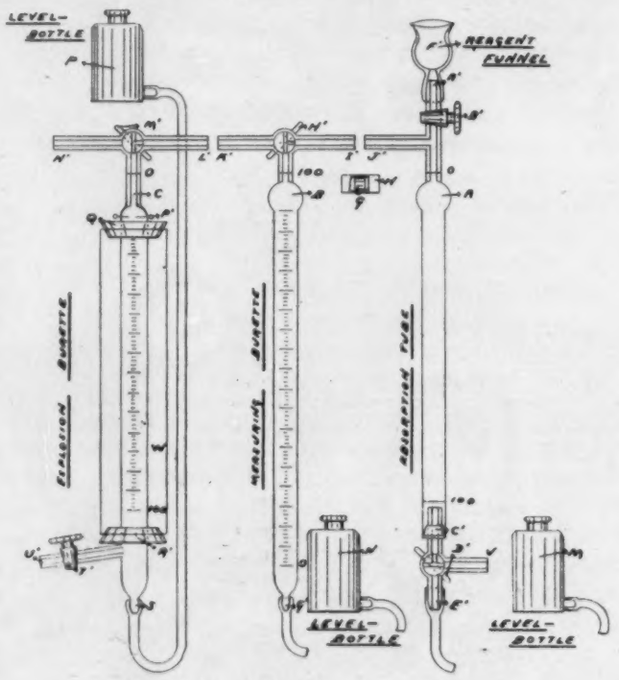

FIGURE 4.

explosion burette is made of heavy glass and there is consequently but little liability to fracture with the exercise of proper care during the explosion.

Operation. Before commencing an analysis, about two liters (approximately two quarts) of water should be saturated with the gas under examination, to prevent, as far as possible, the washing out of the soluble constituents of the gas mixture, previous to their absorption by the reagents. With this apparatus the gas is successively treated with the absorbents, as was done with the improvised tubes shown in Figure 1*, differing in this respect from the Orsat. The absorptions are made in the absorption tube A (Figure 4), and the subsequent measurements in the burette B. In preparing for the analysis the level-bottles M, N and P are nearly filled with the saturated water, the connections on the horizontal capillary tubing between the ends J′ and I′, K′ and L′ being made, stop-

*See THE JOURNAL OF ELECTRICITY, April number.

cocks D′, H′ and M′ are opened to give a passage between the level-bottle M and absorption tube, and both through the horizontal capillary and into the measuring and explosion burettes. A rubber tube should be fastened on the end V of the projecting arm from the stop-cock D′, to carry off the waste liquids to the drain.

Open stop-cock B′ and raise all three level-bottles, filling the entire apparatus with water, thereby expelling all air. Close three-way cock M′ so that the run is just closed to the capillary, bringing the outlet up, the reverse of the former position. (In speaking of three-way stop-cocks the long or through passage will be termed the "run," and the branch at right angles to this the "outlet.") Close stop-cock H′ so that the run and outlet are closed to the capillary and measuring burette respectively, with the outlet down. Close stop-cock B′, taking care that the water overflows at the end A′. Open stop-cock T′ on the explosion burette to allow the air, caught in the capillary portion, to escape; close when water overflows at the end U′. We are now ready to admit the gas sample.

Connection is made at end A′ of the absorption tube with the gas source. The level-bottle M is lowered and stop-cock B′ opened to admit a little more than 100 cubic centimeters of gas. (The actual amount admitted will be a little more than 50 cubic centimeters, inasmuch as all three tubes are graduated to read double the capacity to avoid computation in deriving the percentages.) With stop-cock B′ closed, open stop-cock H′ bringing the outlet up to the main capillary, and the run up and down (the position shown in Figure 4), when connection will be made between the absorption tube and measuring burette. Raise level-bottle M and lower level-bottle N, causing the gas to pass into the burette. Now raise the level-bottle N to a height that will bring the level of the water therein to the zero or lowest graduation on the scale of the burette B. Retain in this position, and after waiting one minute for the walls of the burette to drain, lower level-bottle M a little, causing the water in the burette B to rise to the zero mark; then close stop-cock H′ with the outlet up, when the burette will contain exactly 100 cubic centimeters of gas under atmospheric pressure. The error due to the capillary tubing between the 100 cubic centimeter mark and the stop-cock H′ is of no consequence, since the tubing in this half-sized apparatus is but one millimeter internal diameter, requiring 127.3 millimeters (5 inches) of length to give one-tenth of one cubic centimeter. It might be remarked here that any error consequent upon the retention of air in the capillary tubing, will be slight, but may be readily estimated by measuring the length of the air bubble. The gas remaining in the capillary and absorption tube may now be expelled by raising level-bottle M, opening stop-cocks H′ and M′, to make connections with exit N′ (having the outlets of the three-way cocks up) and stop-cock B′, closing all three, on the overflow of water, to their former positions. Transfer the 100 cubic centimeters of gas by raising the level-bottle N, lowering the level-bottle M, and opening stop-cock H′, so that it communicates with the absorption tube. Have the water rise in the measuring burette until it reaches the absorption tube end of the horizontal capillary, thus causing all the gas to pass over, when stop-cock H′ is to be closed, with outlet up. Place the funnel F′ on the end A′, noticing whether there is any air in the vertical capillary; if so, it can be dislodged by inserting a copper wire, with a little water in the funnel. We are now ready to treat the gas with the reagents.

Determination of Carbon Dioxide. The first determination is, as in former instances, that of the carbon dioxide. The reagent, potassium hydroxide, is poured into the funnel F′, filling the latter about two-thirds full, before opening the stop-cock B′ just enough to allow of the reagent spreading evenly around the bulbed portion of the absorption tube A, and running slowly down the sides. Never allow the reagent in the funnel to quite reach the top of the vertical tube, lest air be admitted. Sufficient of the potassium hydroxide should be added to suit the requirements of the gas under examination, a very little sufficing as a rule. On the admission of the proper amount, close stop-cock B′ and transfer the gas to the measuring burette by opening stop-cock H′ and raising and lowering level-bottles M and N respectively, closing stop-cock H′ as soon as the water from the absorption tube reaches the vertical capillary of the measuring burette. Wait one minute before making the measurement, for the walls of the burette to drain; then, with the level of the water in the measuring burette and level-bottle N at the same height, note the position of the lowest point of the meniscus at the surface of the water, with refererence to the graduations of the scale. This gives the reading under atmospheric pressure, and subtracted from 100, gives the amount of absorption. Transfer the gas to the absorption tube by opening stop-cock H′, raising level-bottle N and lowering level-bottle M, and again treat with potassium hydroxide. Transfer to measuring burette and take the reading under atmospheric pressure. If this corresponds to the former reading, the absorption is complete; if not, more reagent must be added until two consecutive readings agree. It is seldom that one treatment does not suffice, but this precaution should be taken after each absorption. With the gas in the measuring burette, turn the stop-cock D′ so that it communicates with the drain V (position shown in Figure 4); open stop-cock B′ and add water through the funnel F′, rinsing all reagent from the tube. With the tube clean, turn stop-cock D′ to shut off the drain and connect the level-bottle and absorption tube; open stop-cocks H′ and M′ to the horizontal capillary, with outlets up, and raising level-bottle M, fill the absorption tube and capillary with water, closing stop-cocks M′, H′ and B′ as the water overflows from the exit N′ and the end A′ of the vertical tube. Transfer the gas to the absorption tube.

Determination of Illuminants. Fill the funnel F′ two-thirds full with water, and with a small dropping pipette add a few drops of bromine. Partly open stop-cock B′, allowing the bromine water to spread around the bulb and flow down the sides of the absorption tube. The tension of bromine being high, the tube will quickly fill with vapor, when the stop-cock B′ should be closed. Before transferring to the burette for measurement, add potassium

hydroxide (emptying funnel of any bromine water remaining) to absorb the bromine vapors, and then transfer the gas to the measuring burette. Note the reading, which, subtracted from the previous one, gives the percentage of illuminants.

Determination of Oxygen. With the gas in the measuring burette, rinse the absorption tube and capillary well out with water and refill. Transfer the gas to the absorption tube and treat with the next reagent, potassium pyrogallate. Measure the amount of absorption in the measuring burette. This reading, subtracted from the last one, gives the percentage of oxygen.

Determination of Carbon Monoxide. Having rinsed the absorption tube and capillary of the last reagent and filled with water, transfer the gas from the measuring burette and treat with cuprous chloride. After using this, and previous to transferring the gas for measurement, add water to absorb the acid vapors. Transfer, and note the reading, which, subtracted from the last, gives the percentage of carbon monoxide. Especial care should be exercised to make this absorption complete.

(Continuation in next number.)

Fraternal

TRANSMISSION ASSOCIATION MEETING.

The following self-explanatory notice has been sent concerning the forthcoming third annual meeting of the Pacific Coast Electric Transmission Association:

The third annual meeting of the Pacific Coast Electric Transmission Association will be held at the Cliff House, San Francisco, Cal., on June 20, 1899.

The first meeting will be called at 1:00 p. m. At 6:30 a dinner will be served by the Association, which will be followed by informal discussions continuing during the evening.

The second meeting will be called at 11:00 a. m., June 21, and continue at the pleasure of the convention. Accomodations will be found at the Cliff House for such as wish to spend the night there.

The Executive Committee request from the members of the Association (both regular and associate) contributions of papers on subjects of interest to the transmission companies, and urge that immediate notice of subjects selected be sent to the office of the President, 175 Crocker Building, San Francisco, Cal.

From the material already secured, an interesting and profitable convention can be assured, if properly supported by a large attendance from the transmission companies. Kindly assure the Executive Committee *at once* of your attendance at the convention.

Electro-Therapeutics

INCANDESCENT AND ARC LAMPS IN THERAPEUTY.

BRITISH contemporaries of both medical and electrical inclinations are extolling the merits of electric light baths, in which incandescent lamps are used as thermal generators. Certain special advantages have been claimed for them on the ground that the heat energy is from a source at a very high temperature, and is radiated rather than conducted, and also that the light given out by the lamps may have beneficial effects. The baths consist of wooden boxes or cabinets arranged for the reception of the patient, and fitted in with from 30 to 40 incandescent lamps and reflectors. It has been recognized from the use of the apparatus, that the effects are mainly due to radiant heat, and the action of radiant heat from a source at a high temperature is in contrast with that of the heat of lower grade employed in the hot room of a Turkish bath. For instance, the degree of perspiration obtained with an air temperature of 85° F. in the electric cabinet, is equal to that produced in a Turkish bath at 160° F. The diseases in which the treatment has been said to have been found beneficial are rheumatism, asthma, ænemia, neurasthenia, and obesity.

Experiments have also been made upon the therapeutic action of arc lamps, in which the patient is placed in a cabinet with two arc lamps arranged outside, so as to shine into the cabinet through a glass window. The patient is nude, wears dark spectacles, and reclines on a couch between the lamps, and it is claimed by Dr. Margaret Cleaves, in the *New York Medical Journal*, that immediately beneficial action has been obtained from the rays of the arc in chronic pulmonary complaints, such as phthisis, asthma, and bronchitis, while in a case of psoriasis and one of eczematous ulcer, the effect was prompt and good. Attention was first drawn to the subject from statements made as to good effects noted by workmen in electric welding works wherein cures were effected in 25 out of 38 cases, mostly neuralgia, sciatica, lumbago and the like, among the workmen. More extended observations are called for, and it is not unlikely that the arc lamp will take a place in therapeuty. Several independent writers have noted that the arc lamp, either by its light or the emission of ozone or other vapors, has a very decided disinfecting or deodorizing action upon noxious smells; thus an arc lamp set up in a dark basement near offensive closets, has served to dissipate all bad odor therefrom completely.

WIRE FOR RESISTANCE COILS.

German silver, platinum silver, and platinoid are the three alloys generally used for resistance purposes in electrical measuring instruments. Expressing their ingredients by weight, the alloys are as follows: German silver: copper, 4 parts, nickel, 2 parts, and zinc, 1 part; platinum silver: platinum, 1 part, and silver, 2 parts; platinoid: German silver, 49 parts, and tungsten, 1 part.

It is given on the authority of Dr. H. Bunte, of Carlsruhe, that while water gas generates only one-half the heat produced by a like volume of illuminating gas, this discrepancy does not make itself perceptible in the same proportion in the production of light in the Welsbach mantle, for the water gas burner, according to Strache, requires, for the candle hour, about two litres (0.07 cubic foot) of gas, thus substantially no more than illuminating gas in the ordinary Welsbach burner.—*The Gas World.*

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